SPECIFICATION

WHEEL-ACTING FORCE MEASURING DEVICE
INS A1

BACKGROUND OF THE INVENTION

The present invention relates to a wheel-acting force measuring device for detecting a road surface friction force, a normal counterforce and a road surface friction coefficient, which can be used as a component of either an antilock brake system (ABS) for preventing the locking of wheels on application of the hard brake to a vehicle or a traction control system for preventing excessive slippage of wheels during acceleration.

As for such wheel-acting force measuring device for detecting a load surface friction force, a normal counterforce and a road surface friction coefficient, which can be used as a component of either an antilock brake system for vehicles or a traction control system, various types have heretofore been developed and proposed. However, such known devices require a relative-to-ground velocity sensor or a vehicle deceleration sensor to accurately find the vehicle velocity, making the device complicated and presenting a problem of accuracy. Thus, there has been a need for a device for directly measuring dynamic quantities concerning actions between the road surface and the wheels.

To meet this need, the present applicant proposed, in Japanese Patent Application No. Hei 3-130840, a wheel-acting force measuring device comprising a hole formed in or adjacent an axle, a stress sensor having a strain gauge attached thereto, said stress sensor being fixedly embedded in said hole with its strain gauge oriented in a suitable direction according to an intended stress or load, so that it is capable of directly measuring an optional stress or load occurring in or adjacent the axle.

However, there is a problem that detection signals delivered from the stress detecting sensor are influenced by cross talk according to the selected position of the hole since there are produced in or adjacent the axle a complicated shearing strain accompanying a bending deformation caused by a road surface friction force, a vertical stress and a side force acting on the wheel and a shearing strain accompanying a torsional deformation caused by the brake torque during application of the brake.

SUMMARY OF THE INVENTION

In view of such problem, the present invention has for its object the provision of a wheel-acting force measuring device comprising a stress detecting sensor disposed at a stress center axis or stress center point (neutral spot) around the axle acted on by wheel-acting forces from a road surface, so that it is not influenced by cross talk other than road surface friction forces or normal counterforces,

and more particularly a wheel-acting force measuring
device comprising a hole in or adjacent an axle at a brake
caliper angle or an angle close thereto, a stress detecting
sensor fixedly embedded in said hole, so that it is not
influenced by cross talk, and a wheel-acting force
measuring device comprising a hole at a neutral spot free
from cross talk, so that the device is not influenced by
cross talk.

The present invention described in Claim 1 is a wheel-
acting force measuring device comprising a hole in or
adjacent an axle at a brake caliper angle or an angle close
thereto, and a stress detecting sensor fixedly embedded at
the position in said hole which coincides with the stress
center axis of or adjacent the axle.

In the invention described in Claim 1, since a hole is
formed in or adjacent an axle at a brake caliper angle or
an angle close thereto and a stress detecting sensor is
fixedly embedded at the position in said hole which
coincides with the stress center axis of or adjacent the
axle, the cross talk to the output signal from the stress
detecting sensor due to the brake torque can be effectively
excluded.

The present invention described in Claim 2 is a wheel-
acting force measuring device comprising a plurality of
holes formed in or adjacent an axle at a brake caliper
angle or an angle close thereto, stress detecting sensors
fixedly embedded at the positions in said holes which

coincide with the stress center axes of or adjacent the
axle, wherein the detection signal from each said stress
detecting sensor is processed in a signal processing
circuit to derive a specified stress.

In the present invention described in Claim 2, a
plurality of holes are formed in or adjacent an axle at a
brake caliper angle or an angle close thereto and stress
detecting sensors are fixedly embedded at the positions in
said holes which coincide with the stress center axes of or
adjacent the axle, wherein the detection signal from each
said stress detecting sensor is processed in a signal
processing circuit, thereby making it possible to measure a
specific acting force among wheel-acting forces such as a
road surface friction force, a normal counterforce and a
road surface friction coefficient without being influenced
by cross talk due to brake torque.

The present invention described in Claim 3 is a wheel-
acting force measuring device comprising a stress detecting
sensor fixedly embedded in a spindle or an axle at a position
between the brake disk attaching position of a vehicle and
the road-contacting surface of a wheel.

In the present invention described in Claim 3, a stress
detecting sensor is fixedly embedded in a spindle or an axle
at a position between the brake disk attaching position of
a vehicle and the road-contacting surface of a wheel, there
occurs less torsional deformation due to brake torque
during application of the brake and it is possible to

-4-

measure outputs such as a road surface friction force and a normal counterforce having almost no cross talk due to brake torque.

The present invention described in Claim 4 is a wheel-acting force measuring device comprising a stress detecting sensor fixedly embedded in a spindle or an axle at a position between the brake disk attaching position of a vehicle and the road-contacting surface of a wheel at a brake caliper angle or an angle close thereto.

In the present invention described in Claim 4, since a sensor is attached at the position described in Claim 3 at a brake caliper angle or an angle close thereto, there is no torsional deformation due to brake torque during application of the brake and it is possible to measure outputs such as a road surface friction and a normal counterforce having no cross talk due to brake torque.

The present invention described in Claim 5 is a wheel-acting force measuring device as set forth in any one of Claims 1 through 4, comprising a stress detecting sensor and a signal processing circuit which are simultaneously fixedly embedded in a hole formed in or adjacent an axle at a brake caliper angle or an angle close thereto.

In the present invention described in Claim 5, in a wheel-acting force measuring device as set forth in any one of Claims 1 through 4, since a stress detecting sensor and a signal processing circuit are simultaneously fixedly embedded in a hole formed in or adjacent an axle at a brake

-5-

caliper angle or an angle close thereto, there is obtained
a high ratio of signal to noise for the output signal from
the signal processing circuit.

The present invention described in Claim 6 is a wheel-
acting force measuring device comprising a stress detecting
sensor disposed in or adjacent an axle of a vehicle or
around an axle subjected to axle-acting forces and on a
stress center axis capable of excluding cross talk other
than load surface friction forces or normal counterforces
or a stress center axis capable of minimizing the amount of
cross talk.

In the present invention described in Claim 6, since a
stress detecting sensor is disposed in or adjacent an axle
of a vehicle or around an axle subjected to axle-acting
forces and on a stress center axis capable of excluding
cross talk other than load surface friction forces or
normal counterforces or a stress center axis capable of
minimizing the amount of cross talk, it is possible to
measure outputs such as a road surface friction force and a
normal counterforce with cross talk other than the road
surface friction force and normal counterforce.

The present invention described in Claim 7 is a wheel-
acting force measuring device as set forth in any one of
Claims 1 through 6, wherein the strain gauge of the stress
detecting sensor is disposed at an angle of approximately
45 degrees with respect to the horizontal and vertical
stress center axes of or adjacent the axle.

In the present invention described in Claim 7, in a wheel-acting force measuring device as set forth in any one of Claims 1 through 6, the strain gauge of the stress detecting sensor is disposed at an angle of approximately 45 degrees with respect to the horizontal and vertical stress center axes of or adjacent the axle and is fixedly embedded in a hole formed in or adjacent an axle at a brake caliper angle or an angle close thereto, it is possible for the stress detecting sensor to measure a road surface friction force and a normal counterforce acting one a wheel while reducing interference from other wheel-acting forces.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a fragmentary perspective view showing an embodiment of a wheel-acting force measuring device according to the present invention;

Fig. 2 is a fragmentary perspective view showing an example of the stress detecting sensor of the wheel-acting force measuring device according to the present invention;

Fig. 3 is a view showing an example of the signal processing circuit of the wheel-acting force measuring device;

Fig. 4 is a fragmentary perspective view showing another example of the stress detecting sensor of the wheel-acting force measuring device according to the present invention;

Fig. 5 is a view showing another example of the signal

-7-

processing circuit of the wheel-acting force measuring device;

Fig. 6 is a fragmentary perspective view showing another example of the stress detecting sensor of the wheel-acting force measuring device according to the present invention;

Fig. 7 is a fragmentary perspective view showing another example of the stress detecting sensor of the wheel-acting force measuring device according to the present invention;

Fig. 8 is a fragmentary perspective view showing still another example of the stress detecting sensor of the wheel-acting force measuring device according to the present invention;

Fig. 9 is a perspective view showing an example of a device for measuring a road surface friction force and a brake torque or driving torque as wheel-acting forces, said device using a plurality of stress detecting sensors.

Fig. 10 is a perspective view showing an example of a device for measuring a road surface friction force as a wheel-acting force, wherein a signal processing circuit and a stress detecting sensor are embedded in the same hole .

Fig. 11 is a perspective view showing an example of a device for measuring a road surface friction force as a wheel-acting force, wherein a signal processing circuit and a stress detecting sensor are embedded in the same hole, said example showing the use of a horizontal hole.

-8-

Fig. 12 is a perspective view showing an example of a device for measuring a road surface friction force and a brake torque or driving torque as wheel-acting forces, wherein a plurality of stress detecting sensors are used and a signal processing circuit and a stress detecting sensor are embedded in the same hole.

Fig. 13 is a perspective view showing another example of the stress detecting sensor of a device for measuring a brake torque or driving torque as a wheel-acting force;

Fig. 14 is a fragmentary perspective view showing an example of another embodiment of a hole in which the stress detecting sensor of a wheel-acting force measuring device is fixedly embedded;

Fig. 15 is a perspective view showing another embodiment of a stress detecting sensor being fixedly embedded in a hole;

Fig. 16 is a perspective view showing still another embodiment of a stress detecting sensor being embedded in a hole;

Fig. 17 is a view showing an embodiment of embedment of a stress detecting sensor described in Claim 3;

Fig. 18 is a view showing an example in which the stress detecting sensor is embedded with the position of the hole changed; and

Fig. 19 is a view showing an example in which stress detecting sensors for two directions (friction force and normal counterforce) are simultaneously embedded.

-9-

PREFERRED EMBODIMENTS OF THE INVENTION

Herein described are some embodiments, and the scope of the invention is not limited thereto.

An embodiment of a wheel-acting force measuring device for measuring a road surface friction coefficient is shown in Figs. 1, 2 and 3. Fig. 1 shows how a stress detecting sensor is attached. Fig. 2 shows the stress detecting sensor and Fig. 3 shows a signal processing circuit. As an example, a hole is formed adjacent the axle for the non-driven wheels of an automobile having a suspension construction of the strut type often used in automobiles, at a brake caliper angle or an angle close thereto, and a stress detecting sensor is attached at the position in the hole which coincides with the stress center axis of or adjacent an axle. A hole 2 is formed in a lateral surface of an axle 1 (which, in this example, is a knuckle) with its center axis 12 extending in the direction of travel 9 of a wheel 7 at a brake caliper angle 14 or an angle close thereto and intersecting a center line of the axle (stress center axis) 5. The diameter of the hole 5 may be 5 mm to 10 mm. The center axis (stress center axis) of the axle means the center line of a bending deformation (on which center line there occurs neither tensile strain nor compressive strain due to the bending deformation) produced in the axle 1 by a road surface friction force, a normal counterforce and a side force acting on the wheel

-10-

rotating around the axis of the spindle, or the center line
of a torsional deformation (on which center line there
occurs no shearing strain due to the torsional deformation)
produced in the axle 1 by the brake torque during
application of the brake. These approximately coincide
with the center axis of the spindle (the center axis 5 of
the axle). A stress detecting sensor 3 is inserted at the
position in the hole 2 which coincides with the stress
center axis 5 of or adjacent the axle. The stress
detecting sensor 3, as shown in Fig. 2, comprises a base
body 20 in the form of a rectangular parallelopiped made of
plastic material, such as epoxy resin, or metal or
silicone and a strain measuring means attached thereto. As
for the strain measuring means, use is made, for example,
of metal counterforce wire strain gauges. In the figure,
strain gauges 21 through 24 and 31 through 34 are indicated
by line segments on the surfaces of the base body 20. The
strain gauges 21 through 24 and 31 through 34 are attached
to the base body 20 by being adhesively stuck to the
surfaces of the base body 20 or by being embedded in the
base body 20 adjacent its surfaces. It is preferable to
attach the strain gauges 21 through 24 and 31 through 34
such that each forms an angle of 45 degrees with respect to
the y-axis. The stress detecting sensor 3 is inserted in
the hole 2 and placed on the center line of the axle
(center axis 5 of the axle). Further, the base body 20 is
positioned such that the x-axis, y-axis and z-axis

-11-

respectively coincide with the direction of travel 9 of the wheel, the axle direction 10 and the vertical direction 11. It is preferable to position it such that the upper surface of the stress detecting sensor (a surface whose normal line direction is the z-direction) is located above the center line of the axle and its lower surface (another surface whose normal line direction is the z-direction) is located below the center line of the axle and such that said tensile strain or compressive strain due to the bending deformation produced by a road surface friction force, a normal counterforce and a side force acting on the wheel has the same value on the opposite surfaces. The greater the distance between the upper and lower surfaces, the greater the the importance of this positioning. Similarly, it is preferable to position it such that the front surface of the stress detecting sensor (a surface whose normal line direction is the x-direction) and its rear surface (another surface whose normal line direction is the x-direction) are located on opposite sides of the stress center line of the axle and such that said strain due to the bending deformation or torsional deformation has the same value on the opposite surfaces. The hole 2 will be filled with a filler 4 (spacing material) according to the need. The filler 4 sufficiently fills the space around the stress detecting sensor 3 to fix the latter in position. Thereby, the strain gauges 21 through 24 and 31 through 34 are effectively fixedly embedded in the hole 2 at the

-12-

predetermined positions and in predetermined directions.

Fig. 3 shows a signal processing circuit, wherein the sets of strain gauges 21, 22, 23, 24 and 31, 32, 33, 34 are respectively combined to form bridges which are electrically connected by electric signal wires 8 to an amplifying circuit 41 comprising a dc source 42 and an amplifier 43 and an amplifying circuit 44 comprising a dc source 45 and an amplifier 46. The road surface friction force acting on the wheel produces shearing strains in the upper and lower surfaces of the stress detecting sensor. The strain gauges 21 through 24 sense this shearing strain. The amplifying circuit 41 delivers a voltage signal which is proportional to said shearing strain, i.e., the road surface friction force.

In addition to the strain gauges 21 through 24 being combined to form a bridge, they are disposed adjacent the center axis of the axle at a brake caliper angle or an angle close thereto so as to sense said shearing strain; therefore, cross talk to the output signal due to said bending deformation and torsional deformation can be minimized. That is, this arrangement realizes a wheel-acting force measuring device for measuring road surface friction forces with high precision. Likewise, the normal counterforce acting on the wheel produces shearing strains in the front and rear surfaces of the stress detecting sensor. The strain gauges 31 through 34 sense this shearing strain. The amplifying circuit 44 delivers a

-13-

voltage signal which is proportional to said shearing
strain, i.e., the normal counterforce. In addition to the
strain gauges 31 through 34 being combined to form a
bridge, they are disposed adjacent the center axis of the
axle at a brake caliper angle or an angle close thereto so
as to sense said shearing strain; therefore, cross talk to
the output signal due to said bending deformation and
torsional deformation can be minimized. That is, this
arrangement realizes a wheel-acting force measuring device
for measuring normal counterforces with high precision. By
delivering the output signals from the amplifying circuits
41 and 44 to an arithmetic circuit 47, it is possible to
measure the road surface friction coefficient. In this
case, the arithmetic circuit 47 calculates the quotient of
the road surface friction force by the normal counterforce
and thereby delivers a signal indicating the road surface
friction coefficient.

In the present embodiment, since the space around the
stress detecting sensor 3 in the hole 2 is filled with a
synthetic resin, such as epoxy resin, or the like, there
is a merit that the strain gauges 21 through 24 and 31
through 34 are protected from the outside.

To measure either the road surface friction force or
the normal counterforce alone, a stress detecting sensor 3
shown in Fig. 4 may be used in place of the stress
detecting sensor 3 shown in Fig. 2. It is preferable that
the strain gauges 21 through 24 be attached so that each

-14-

forms an angle of 45 degrees with respect to the y-axis.
To measure the road surface friction force, it is
preferable that the x-axis, y-axis and z-axis shown in Fig.
4 coincide with the vertical direction 11, the direction of
travel 9 of the wheel, and the direction 10 of the axle,
respectively. To measure the normal counterforce, it is
preferable that the x-axis, y-axis and z-axis shown in
Fig. 4 coincide with the direction of travel 9 of the
wheel, the direction 10 of the axle, and the vertical
direction 11, respectively. The relation between the
attaching position and the center line of the axle is the
same as in the case of the stress detecting sensor shown in
Fig. 2. The strain gauges 21 through 24 are connected to
the signal processing circuit shown in Fig. 5. That is,
they are combined to form a bridge, which is connected to
the amplifying circuit 41. The amplifying circuit 41
delivers a signal indicating the road surface friction
force or the normal counterforce.

To measure the side force as a wheel-acting force, a
stress detecting sensor shown in Fig. 6 is used, wherein
the strain gauges 21 through 24 are attached to extend in
the direction of the y-axis or z-axis and the x-direction,
y-direction and the z-direction coincide with the direction
of travel 9 of the wheel, the direction 10 of the axle, and
the vertical direction 11, respectively, and are connected
in the same manner as in the signal processing circuit
shown in Fig. 5. Thereby, a wheel-acting force measuring

-15-

device can be constituted.

Other embodiments of stress detecting sensors are shown
in Figs. 7 and 8. In these embodiments, the stress
detecting sensor comprises a bar-like structure 51, a flat
plate 52 formed on one end surface of said structure 51 and
measuring strain gauges 21 through 24 attached to said flat
plate 52. In this case also, there is shown an example in
which metal resistance wire strain gauges are attached as
measuring gauges. The bar-like structure 51 may be of
plastic material or the same material as that of the axle 1
in which the stress detecting sensor is embedded. The
strain gauges 21, 22, 23 and 34 are attached to the flat
plate 52 with the axis of each strain gauge forming an
angle of 45 degrees with respect to the center axis 50 and
the bar-like structure is fixedly attached in the hole 2 of
said axle 1. That is, it is fixedly attached by hammering,
bonding, soldering, welding or shrink fitting. The
presence of the bar-like structure 51 provides a merit that
in fixedly embedding the stress detecting sensor 3 in the
hole 2, the position and direction of the strain gauges can
be easily set as predetermined. Particularly, in the
stress detecting sensor shown in Fig. 8, the width of the
flat plate 52 is smaller than the diameter of the bar-like
structure 51. As a result, there is a merit that in
fixedly embedding the stress detecting sensor 3 in the hole
2, the flat plate 52 is prevented from being subjected to
deformation, such as torsional deformation, caused as by

-16-

rotation, which would produce irrelevant strain or damage of the flat plate 52.

Fig. 9 is an enlarged view showing the hole 2 vertically formed in the axle. In this example, two stress sensors shown in Fig. 4 are used. The are placed so that the x-, y- and z-directions respectively coincide with the the vertical direction 11, the direction of travel 9 of the wheel, and the direction 10 of the axle. By connecting the sets of strain gauges 21 through 24 and 31 through 34 in the same manner as in the signal processing circuit shown in Fig. 3, it is possible to deliver signals indicating the road surface friction force and driving torque or the brake torque which is produced on actuation of the braking device. If the sum of outputs from the two amplifying circuits 41, 44 is calculated, the road surface friction force is obtained and if the difference therebetween is calculated, said torque is obtained. In this example, one stress detecting sensor 3 is placed on the center axis 5 of the axle, but the same effect can be obtained even if both are placed off the center axis 5.

Fig. 10 shows an example of measuring the road surface friction force, wherein the axle is formed with a vertical hole and the amplifying circuit 41 is embedded in the hole 2 together with the stress detecting sensor 3. Embedding the amplifying circuit 41 in the hole 2 is made possible by using the present day circuit integration technology. By placing the amplifying circuit 41 adjacent the stress

-17-

detecting sensor 3, it is possible to provide on a signal
wire 53 an output signal which has less noise.

Fig. 11 shows an example in which the axle is formed
with a horizontal hole in which the amplifying circuit 41
together with the stress detecting sensor 3 is embedded as
in Fig. 10 so as to measure the road surface friction
force.

Fig. 12 shows an example of a device using two stress
detecting sensors for measuring the road surface friction
force and the driving torque or brake torque acting on the
wheel, wherein a signal processing circuit 54 comprising
amplifying circuits 41 and 44 and an arithmetic circuit 47
is embedded in the hole together with the stress detecting
sensor 3. The numeral 55 denotes an output signal wire for
the signal processing circuit 54. In addition, if
semiconductor strain gauges are used, the amplifying
circuit and arithmetic circuit can be integrally embedded
in the hole.

Fig. 13 shows an example of using a single stress
detecting sensor 3 to measure the brake torque or driving
torque. If the strain gauges are connected in the order
21, 23, 22, 24 with 22 and 23 interchanging their positions
as shown, the device for measuring said torque can be
constructed.

Fig. 14 shows an example in which a hole 2 is formed to
extend in the axle direction 10. The position of the hole
is not limited to the knuckle position in the example shown

in Fig. 1; for example, it may be formed in a portion
beyond the same further to the front end portion, or the
so-called spindle 56. The embodiment shown in Fig. 14 has
a merit that while using stress detecting sensors of the
same type as in Fig. 7 or 8, the same device can be used as
a road surface friction force detecting device or a normal
counterforce detecting device simply by changing the
directions of such sensors.

In addition, Figs. 1 and 9 through 13 have shown
embodiments in which the stress detecting sensor 3 is
fixedly embedded in the hole 2 using the filler 4 (spacing
agent), the invention is not limited thereto; for example,
as shown in Fig. 15, a stress detecting sensor 3 with
strain gauges attached to the front surface, back surface
or front and back surfaces or interior of a disk-like base
block of plastic material, metal base or semiconductor
base, such as silicone, having a diameter approximately
equal to the inner diameter of the hole 2 is fixedly
embedded in the hole 2 through a sealing agent or adhesive
agent or directly, whereby the peripheral surface of the
disk-like base block and the inner peripheral wall of the
hole, which contact each other, are fixed together.

Further, as shown in Fig. 16, a stress detecting sensor
3 having strain gauges attached to the front and/or back or
interior of a planar substrate in the form of a semiconductor
base of plastic material, metal base or silicone may be
embedded in a hole in such a manner that their contact

surfaces, or the lateral peripheral surface of the planar substrate and the inner peripheral wall are fixed together through the intermediary of a sealant or adhesive agent or directly by force-fitting

Fig. 17 shows an example of the embedment of a stress detecting sensor in Claim 3. This figure is a plan view of the spindle 56 of an axle of a vehicle. At any position which is located inwardly of a position 61 located most inwardly (vehicle body side) of the area of contact between the wheel and the road, the friction force between the wheel and the road surface and the normal counterforce, acting on the wheel, can be measured. Further, at a position located outwardly (wheel side) of the brake disk attaching position, most of the force due to the torsional deformation during application of the brake is transmitted to the inner side (vehicle body side), never measured. Therefore, the stress detecting sensor 3 embedded in a placed between the inside (vehicle body side) of the position 61 of the hole 2 and the outside (wheel side) of the position 62 is free from cross talk caused by shearing strain due to torsional deformation during application of the brake.

Let an arrow 60 be the direction of travel of the vehicle, and the stress detecting sensor 3 serves as a road surface friction force detecting sensor. Further, if the arrow 60 indicates the vertical direction, then the stress detecting sensor 3, as shown in Fig. 18, serves as a sensor

for detecting the normal counterforce acting on the axle.
Further, as shown in Fig. 19, if two stress detecting
sensors 3 are simultaneously embedded in a hole 2 in such a
manner as to satisfy said two directions, then it serves as
a road surface friction coefficient detecting sensor,
capable of detecting the road surface friction force and
the normal counterforce at the same time.

Further, in the embodiment shown in Fig. 17, the hole 2
has been formed from the vehicle body side; however, it is
only necessary that the sensor be embedded between the
positions 61 and 62; for example, it may be formed from the
front end of the axle opposite to the hole 2 or it may be
formed throughout the axle. Further, the same merits as
in this embodiment can also be obtained even if such hole,
as shown in Figs. 18 and 19 is formed between the
positions 61 and 62 and in a direction normal to the hole 2
of Fig. 17.

In addition, in the above embodiments, the stress
detecting sensor has been shown embedded in the stress
center axis of or adjacent the axle; however, the invention
is not limited thereto, and a stress detecting sensor may
be disposed at the stress center point (neutral spot) around
an axle such as in or adjacent an axle.

ADVANTAGES OF THE INVENTION

According to the present invention, cross talk to the
stress detecting sensor caused by the brake torque can be

effectively eliminated, so that wheel-acting forces, such as the road surface friction force, normal counterforce, road surface friction coefficient, side force, brake torque and driving torque which act on the wheels of a vehicle can be measured with ease. If the invention is applied to an antilock brake system, it is possible to minimize the braking distance irrespective of road surface conditions while achieving the object of antilocking. Furthermore, there is no need to provide a complicated device for measuring the vehicle velocity. In the case of a traction control system, it is possible to minimize the accelerating distance irrespective of road surface conditions. Thus, the invention is highly effective as it greatly improves the performance of antilock brake systems and traction control systems.